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ESE – 2019 MAINS
OFFLINE TEST SERIES

ELECTRONICS & TELECOMMUNICATION ENGINEERING (E&T)

TEST – 14
SOLUTIONS

All Queries related to **ESE – 2019 MAINS Test Series** Solutions are to be sent to the following email address

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01. (a)
Sol:
(i) 16 levels = M = 2^k
k = 4 bits/symbol
$$R_s = \frac{R}{\log_2 M} = \frac{10\,\text{Mbits/s}}{4\,\text{bits/symbol}} = 2.5 \text{ Msymbols/s}$$
$$\text{Minimum Bandwidth} = \frac{R_s}{2} = 1.25\text{MHz}$$
(ii) $W = \frac{1}{2}(1+\alpha)\, R_s$
1.375MHz = (1 + α)1.25 MHz
$\alpha = 0.1$

01. (b)
Sol:
(i) $$G(s)\Big|_{\tau_D = 0} = G_1(s) = \frac{1}{s(s+1)(s+2)}$$
$$\left|G_1(s)\right|_{\omega=\omega_{gc}=0.466} = 1$$
i.e gain cross over frequency ω_{gc}= 0.466 rad/sec
$$PM = 180° + \angle\frac{1}{j\omega(j\omega+1)(j\omega+2)}$$
$$= 180° - \left(90° + \tan^{-1}\frac{\omega_{gc}}{1} + \tan^{-1}\frac{\omega_{gc}}{2}\right)$$
$$= 180° - (90° + 25° + 13°)$$
PM = 52°
(ii) If dead time increases the stability of the system decreases.
(iii) For just stability PM = 0°
GM = 0 dB
$$PM = 0° = 180° + \angle G(s)\Big|_{\omega=\omega_{gc}}$$
$$\Rightarrow \quad 0 = \pi + \angle\frac{e^{-j\omega\tau_D}}{j\omega(j\omega+1)(j\omega+2)}\Bigg|_{\omega=\omega_{gc}}$$
$$\Rightarrow \quad 0 = \pi - \left(\omega_{gc}\tau_D + \frac{\pi}{2} + \tan^{-1}\frac{\omega_{gc}}{1} + \tan^{-1}\frac{\omega_{gc}}{2}\right)\Bigg|_{\omega_{gc}=0.466}$$
$$\Rightarrow \omega_{gc}\tau_D = 52°$$
$$\Rightarrow \omega_{gc}\tau_D = 0.9075$$
$$\Rightarrow \tau_D = \frac{0.9075}{0.466} = 1.947$$
$$\tau_D = 1.947$$

For $\tau_D = 1.947$ system is just stable

$\tau_D < 1.947$ stable

$\tau_D > 1.947$ unstable

01. (c)

Sol: $H(z) = \sum_{n=-\infty}^{\infty} h(n) z^{-n} = 1 + 2z^{-1} + 3z^{-2} + 2z^{-3}$

$$Y(z) = \sum_{n=-\infty}^{\infty} y(n) z^{-n} = 1 + 3z^{-1} + 7z^{-2} + 10z^{-3} + 10z^{-4} + 7z^{-5} + 2z^{-6}$$

$$X(z) = \frac{Y(z)}{H(z)} = \frac{1 + 3z^{-1} + 7z^{-2} + 10z^{-3} + 10z^{-4} + 7z^{-5} + 2z^{-6}}{1 + 2z^{-1} + 3z^{-2} + 2z^{-3}}$$

$$\begin{array}{r|l} & 1+z^{-1} + 2z^{-2} + z^{-3} \\ 1+2z^{-1}+3z^{-2}+2z^{-3} & 1+3z^{-1}+7z^{-2}+10z^{-3}+10z^{-4}+7z^{-5}+2z^{-6} \\ & 1+2z^{-1}+3z^{-2}+2z^{-3} \\ \hline & z^{-1}+4z^{-2}+8z^{-3}+10z^{-4} \\ & z^{-1}+2z^{-2}+3z^{-3}+2z^{-4} \\ \hline & 2z^{-2}+5z^{-3}+8z^{-4}+7z^{-5} \\ & 2z^{-2}+4z^{-3}+6z^{-4}+4z^{-5} \\ \hline & z^{-3}+2z^{-4}+3z^{-5}+2z^{-6} \\ & z^{-3}+2z^{-4}+3z^{-5}+2z^{-6} \\ \hline & 0 \end{array}$$

$X(z) = 1 + z^{-1} + 2z^{-2} + z^{-3}$

$x(n) = \{1, 1, 2, 1\}$

01. (d)

Sol:

(i) Addressing modes are classified into 2 classes

(i) **Non-computable:** These modes do not require any computation to obtain effective address.

(ii) **Computable:** These modes require some computation to obtain effective address.

Addressing modes

Non-Computable

→Implied mode

→Immediate mode

→Direct mode

→Indirect mode

→Register mode

→Register Indirect Mode

Computable

→Indexed mode

→Base Register mode

→Pc-Relative mode

→Auto increment | Auto increment mode

(ii) In computer architecture, cycles per instruction (aka clock cycles per instruction, clocks per instruction, or CPI) is one aspect of a processor's performance: the average number of clock cycles per instruction for a program or program fragment. It is the multiplicative inverse of instructions per cycle.

The average of Cycles Per Instruction in a given process is defined by the following:

$$\text{CPI} = \frac{\sum_i (\text{IC}_i)(\text{CC}_i)}{\text{IC}}$$

Where IC_i is the number of instructions for a given instruction type i, CC_i is the clock-cycles for that instruction type and $IC = \Sigma_i (IC_i)$ is the total instruction count.

01. (e)

Sol: **Given:** $\vec{H} = (2\hat{a}_y - j5\hat{a}_z)e^{-j25x}$

$$\vec{H}^* = (2\hat{a}_y + j5\hat{a}_z)e^{j25x}$$

$$\vec{H}\vec{H}^* = |\vec{H}|^2$$

$$|\vec{H}| \text{ or } H \text{ or } H_0 = \sqrt{\vec{H}.\vec{H}^*} = \sqrt{2^2 + 5^2} = \sqrt{29}\ \text{A/m}$$

$$E \text{ or } E_0 = 1500\ \text{V/m}$$

$$\beta = 25\ \text{rad/m}$$

$$f = 400\text{MHz (or) } 400 \times 10^6\text{Hz}$$

$$\frac{E_0}{H_0} = \eta = \sqrt{\frac{\mu}{\varepsilon}} \text{ or } 120\pi\sqrt{\frac{\mu_r}{\varepsilon_r}} \text{ (or) } 377\sqrt{\frac{\mu_r}{\varepsilon_r}}$$

$$\therefore \eta = \frac{1500}{\sqrt{29}} = 278.54$$

$$377\sqrt{\frac{\mu_r}{\varepsilon_r}} = 278.54$$

$$\Rightarrow \sqrt{\frac{\mu_r}{\varepsilon_r}} = 0.7388$$

Phase shift constant, $\beta = \omega\sqrt{\mu_0\varepsilon_0\mu_r\varepsilon_r}$

$$\Rightarrow 25 = 2\pi \times 400 \times 10^6 \times \frac{1}{3 \times 10^8} \times \sqrt{\mu_r\varepsilon_r}$$

$$\Rightarrow \sqrt{\mu_r\varepsilon_r} = 2.984$$

$$\sqrt{\mu_r\varepsilon_r} = 2.984 \text{ ----- (1)}$$

$$\sqrt{\frac{\mu_r}{\varepsilon_r}} = 0.7388 \text{ ----- (2)}$$

Consider (1)$\times$ (2) $\Rightarrow \mu_r = 2.204$

$$\frac{(1)}{(2)} \Rightarrow \varepsilon_r = 4.038$$

01. (f)
Sol:

Evaporation	Sputtering
1. It is limited to lighter elements and simple compounds	1. Virtually anything can be sputtered.
2. Low energy ions/atoms (~0.1ev)	2. High energy ions/atoms (1 - 10 eV)
3. High purity thin films is possible	3. Lower purity due to the implantation of gas atoms in the films
4. Less dense films	4. Dense films
5. Large grain size	5. Smaller grain size
6. Requires high vacuum	6. Can use a low vacuum
7. Directional	7. Poor directionality
8. Components evaporate at different rates	8. Components deposited at similar rates
9. Adhesion problems present	9. Good Adhesion
10. Since it is directional it can use for lift-off	10. Provides good step coverage

02. (a)
Sol:

(i) $$G = \begin{bmatrix} 1 & 1 & 1 & 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 & 0 & 1 & 0 \\ 1 & 1 & 0 & 1 & 0 & 0 & 0 & 1 \end{bmatrix}$$

$$H = \left[I_{m-k} \vdots P^T\right] = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 1 & 0 & 1 \\ 0 & 1 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 1 & 1 & 1 \end{bmatrix}$$

(ii) $t = \left[\frac{d_{min} - 1}{2}\right] = \left[\frac{4-1}{2}\right] = 1$

(iii) $s = rH^T = [1\ \ 0\ \ 1\ \ 0\ \ 1\ \ 0\ \ 1\ \ 0]\,H^T = [0\ \ 0\ \ 1\ \ 1]$ Not a codeword

(iv) $s = [0\ \ 1\ \ 0\ \ 1\ \ 1\ \ 1\ \ 0\ \ 0]\ H^T = [0\ \ 0\ \ 0\ \ 0]$ Yes, it is a codeword

02. (b)
Sol:

(i) T.F = G(s) = $C(sI - A)^{-1} B$

$$(sI - A)^{-1} = \begin{bmatrix} s & -1 \\ 2 & s+3 \end{bmatrix}^{-1}$$

$$= \begin{bmatrix} s+3 & 1 \\ -2 & s \end{bmatrix} \frac{1}{s^2+3s+2}$$

$$(sI - A)^{-1} B = (sI - A)^{-1} \begin{bmatrix} 0 \\ 2 \end{bmatrix} = \begin{bmatrix} 2 \\ 2s \end{bmatrix} \frac{1}{(s+1)\,(s+2)}$$

$$G(s) = [1\ \ 1]\ (sI - A)^{-1} B$$

$$= \frac{2(s+1)}{(s+1)(s+2)} = \frac{2}{(s+2)}$$

(ii) $\begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$, u(t) = unit step $\rightarrow \frac{1}{s}$

$$\begin{bmatrix} X_1(s) \\ X_2(s) \end{bmatrix} = (sI - A)^{-1} \begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix} + (sI - A)^{-1} B\, U(s)$$

$$= \begin{bmatrix} \frac{1}{(s+1)\,(s+2)} \\ \frac{s}{(s+1)\,(s+2)} \end{bmatrix} + \begin{bmatrix} \frac{2}{s\,(s+1)\,(s+2)} \\ \frac{2}{(s+1)\,(s+2)} \end{bmatrix}$$

$Y(s) = X_1(s) + X_2(s)$

$y(t) = x_1(t) + x_2(t)$

$$\frac{1}{(s+1)\,(s+2)} = \frac{1}{s+1} - \frac{1}{s+2}$$

$$\frac{s}{(s+1)\,(s+2)} = \frac{-1}{s+1} + \frac{2}{s+2}$$

$$\frac{1}{s\,(s+1)\,(s+2)} = \frac{1}{2}\frac{1}{s} - \frac{1}{s+1} + \frac{1}{2}\frac{1}{s+2}$$

$$X_1(s) = \frac{1}{s+1} - \frac{1}{s+2} + \frac{1}{s} - \frac{2}{s+1} + \frac{1}{s+2}$$

$$= \frac{1}{s} - \frac{1}{s+1}$$

$$X_2(s) = -\frac{1}{s+1} + \frac{2}{s+2} + \frac{2}{s+1} - \frac{2}{s+2}$$

$$= \frac{1}{s+1}$$

$x_1(t) = 1\,u(t) - e^{-t}\,u(t)$,

$x_2(t) = e^{-t}\,u(t)$

$y(t) = x_1(t) + x_2(t) = 1\,u(t)$

02. (c)

Sol:

(i) At higher frequency attenuation is more hence more power will be required for signal transmission to ensure that it reaches the destination with the required minimum power. Higher power requirements involve the use of high power amplifiers with high ratings and heat sinks. This will increase the weight and power supply ratings will not make any difference. However for the satellite this will result in higher power consumption, which results in avoidable in efficiency.

(ii) Orbital Perturbation:

Keplerian orbit is ellipse whose properties are constant with respect to time. In practice, the satellite and earth respond to many other influences including asymmetry of earth's gravitational field, the gravitational field of sun and moon and solar pressure. All of these interfering forces causes the true orbit ot be different from simple Keplerian ellipse. Result in pertured orbit.

(iii) Microwave communications are used for short range communications, while satellite communications can be established over long distances, Microwave communications are ideal for television and radio broadcast, while satellite communications are used for communicating to ships and aircrafts, relaying telephone calls and providing communications to remote areas.

Microwave signal range does not extend for beyond the visible horizon. Receivers we commonly placed on top of high buildings or hilltop and mountain peaks because the higher the receiver is, the farther the signal can be broadcast.

(iv) Major sources of error in GPS receiver:

1. Satellite clock and ephemeris errors
2. Selective availability
3. Ionospheric delay
4. Tropospheric delay
5. Receiver noise
6. Multipath.

03. (a)

Sol:

(i) $h(t) = e^{-at}.\cos bt.u(t) \qquad h(n) = e^{-anT}.\cos(bnT)u(nT)$

$$H(z) = \sum_{n=0}^{\infty} h(n) z^{-n} = \sum_{n=0}^{\infty} e^{-anT}.\cos bnT.z^{-n}$$

$$= \sum_{n=0}^{\infty} e^{-anT} z^{-n} \left[\frac{e^{jnbT} + e^{-jnbT}}{2}\right]$$

$$= \frac{1}{2}\left[\sum_{n=0}^{\infty} \left(e^{-(a-jb)T} z^{-1}\right)^n + \left(e^{-(a+jb)T} z^{-1}\right)^n\right]$$

$$= \frac{1}{2}\left[\frac{1}{1-e^{-(a-jb)T}z^{-1}} + \frac{1}{1-e^{-(a+jb)T}z^{-1}}\right]$$

$$H(z) = \frac{1}{2}\left[\frac{1-e^{-(a+jb)T}z^{-1} + 1 - e^{-(a-jb)T}z^{-1}}{\left(1-e^{-(a-jb)T}z^{-1}\right)\left(1-e^{-(a+jb)T}z^{-1}\right)}\right]$$

$$H(z) = \frac{1}{2}\left[\frac{1-e^{-aT}.e^{-jbT}z^{-1} + 1 - e^{-aT}z^{-1}.e^{jbT}}{1-e^{-(a+jb)T}z^{-1} - e^{-(a-jb)T}z^{-1} + e^{-(a+jb+a-jb)T}z^{-2}}\right]$$

$$H(z) = \frac{1}{2}\left[\frac{2-e^{-aT}z^{-1}\left[e^{-jbT}+e^{jbT}\right]}{1-e^{-aT}z^{-1}\left[e^{-jbT}+e^{jbT}\right]+e^{-2aT}z^{-2}}\right]$$

$$H(z) = \frac{1}{2}\left[\frac{2-2e^{-aT}\cos bTz^{-1}}{1-2e^{-aT}z^{-1}\cos(bT)+e^{-2aT}z^{-2}}\right]$$

$$H(z) = \frac{1-e^{-aT}\cos bTz^{-1}}{1-2e^{-aT}z^{-1}\cos(bT)+e^{-2aT}z^{-2}}$$

(ii) $$\frac{X(z)}{z} = \frac{z^2 - 4z + 5}{(z-1)(z-2)(z-3)}$$

$$\frac{X(z)}{z} = \frac{A}{z-1} + \frac{B}{z-2} + \frac{C}{z-3}$$

$$\frac{X(z)}{z} = \frac{1}{z-1} - \frac{1}{z-2} + \frac{1}{z-3}$$

$$X(z) = \frac{z}{z-1} - \frac{z}{z-2} + \frac{z}{z-3}$$

(1) $2 < |z| < 3 = (|z| > 2) \cap (|z| < 3) \cap (|z| > 1)$
So, $x(n) = u(n) - (2)^n u(n) - (3)^n u(-n-1)$

(2) $|z| > 3 = (|z| > 1) \cap (|z| > 2) \cap (|z| > 3)$
So, $x(n) = u(n) - (2)^n u(n) + (3)^n u(n)$

(3) $|z| < 1 = (|z| < 1) \cap (|z| < 2) \cap (|z| < 3)$
So, $x(n) = -u(-n-1) + (2)^n u(-n-1) - (3)^n u(-n-1)$

03. (b)
Sol:

(i) Phase difference $\alpha = 0°$

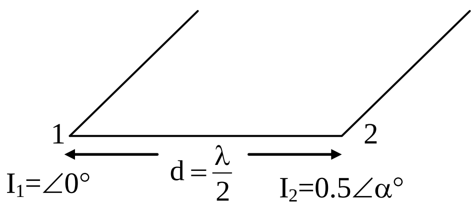
Total field strength at far-field zone is given by

$E_T = E_1 + E_2 = E_0\, e^{j0} + 0.5\, E_0\, e^{j\Psi}$

$\Psi = \beta d \cos\theta + \alpha$

$$\Psi = \frac{2\pi}{\lambda} \times \frac{\lambda}{2} \cos\theta + 0 = \pi\cos\theta$$

$E_T = E_0\,[1 + 0.5\, e^{j\pi\cos\theta}]$



Direction of maximum

$\pi \cos\theta_{max} = 0$

$$\therefore \theta_{max} = \frac{\pi}{2} \text{ (or) } 90°$$

Direction of minimum:

$\pi \cos\theta_{min} = \pm\pi$

$\cos\phi_{min} = \pm 1$

$\theta_{min} = 0$ and π^c (or) $0°$ and $180°$

(ii) Phase difference $\alpha = \frac{\pi}{2}$

$\Psi = \beta d\cos\theta + \alpha = \pi\cos\theta + \frac{\pi}{2}$

$$E_T = E_0\left[1 + 0.5 e^{j\left(\pi\cos\theta + \frac{\pi}{2}\right)}\right]$$

Direction of maximum:

$$\pi\cos\theta_{max} + \frac{\pi}{2} = \pm 2n\pi;\ n = 0, 1, 2, \text{------}$$

For n = 0 ($\because \cos\theta_{max} \le 1$)

$$\pi\cos\theta_{max} + \frac{\pi}{2} = 0$$

$$\cos\theta_{max} = -\frac{1}{2}$$

$\therefore\ \theta_{max} = 120°$

Direction of minimum:

$$\pi\cos\theta_{min} + \frac{\pi}{2} = \pm(2n+1)\pi$$

$$\cos\theta_{min} = \pm(2n+1) - \frac{1}{2}$$

For n = 0

$$\cos\theta_{min} = +1 - \frac{1}{2} = \frac{1}{2}$$

$\therefore\ \theta_{min} = 60°$

03. (c)

Sol: Given that

Area = 10,000 km^2

Population = 2.5 million

Cell frequency reuse = 12

(i) Number of channels per cell

$$C = \frac{\text{Allocated Spectrum}}{\text{channel width} \times \text{frequency reuse}}$$

$$C = \frac{4\times 10^8}{6\times 10^4 \times 12}$$

C ≅ 56 channels/cell

(ii) Total number of cells (N_c)

We have area of the cell (Hexagon) to be 2.5981 R^2

Thus, each covers 2.5981 × $(3.06)^2$ = 24.3km^2

Total number of cells are $N_c = \frac{\text{Total area}}{\text{Coverage of each cell}}$

$$= \frac{10,000}{24.3}$$

N_c = 411 cells

(iii) Maximum carried Traffic = Number of cells × Traffic intensity per cell

= 411 × 45

= 18,495 Erlangs

(iv) Total number of users $= \frac{\text{Total traffic time}}{\text{Traffic per user}}$

$$= \frac{18,495}{0.03}$$

= 616,500 users

04. (a)

Sol: Network Topology:

- Arrangement of hosts in a communication network
- Network Topology are of two types

  i) Point to point topology ii) Point to Multipoint topology

i) Point to Point topology:

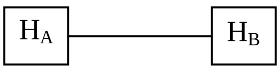
- Direct link, no any channel access protocol required
- Point to Point Protocol (PPP) is used for communication
- Types of point to point topology

  A) Point to Point Link

  B) Mesh topology

  C) Star topology

A) Point to Point link:



Single communication link between two end communication point for serial communication

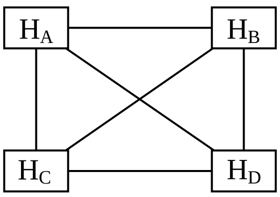
B) Mesh topology: Mesh topologies are of 2 types:

I. Fully mesh topology

II. Partial mesh topology

I. Fully mesh topology:

- Separate communication link between every pair of hosts
- If N number of hosts then $\frac{N\times(N-1)}{2}$ links are required.



Advantages:

1. Fastest communication among all topologies
2. Secure communication
3. Parallel communication

Disadvantages:

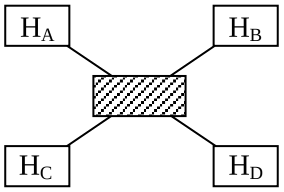
1. Installation cost is very high due to too many links
2. Poor link utilization

II. Partial Mesh Topology

- Some nodes are organized in a full mesh scheme but others are only connected to one or two in the network.
- Partial mesh topology is commonly found in peripheral networks connected to a full meshed backbone.

C) Star topology:

- Multiple hosts are connected to centralized server
- Centralized server can be Hub, Switch or Router



Advantages:

1. Insertion and Removal of hosts are too easy
2. Star topology can be extended in daisy chain manner

Disadvantages:

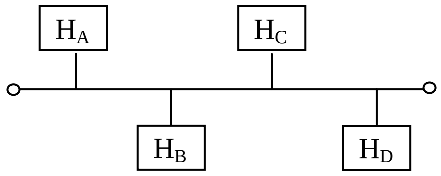
1. If centralized server fail then topology will not work
2. More processing overhead at centralized server

ii) Point to multipoint topology:

- Multiple hosts are connected to common broadcast media
- One sender and all are receiver
- Channel access mechanism required

Types of point to multipoint topology:
A) Bus topology
B) Ring topology

A) Bus topology:



- Multiple hosts are connected to common coaxial cable (backbone media)
- Different channel access protocols are ALOHA, CSMA and Token Bus

Advantages:

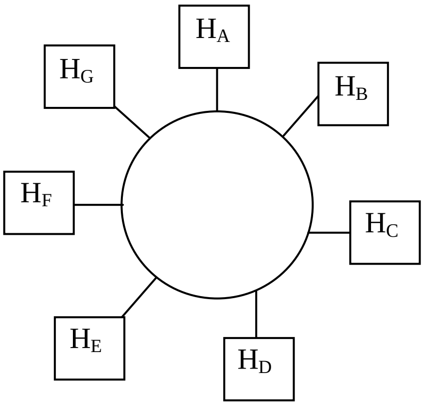
1. Installation cost is very less among all topologies
2. Preferred for large area networks

Disadvantages:

1. If common channel fail then topology will not work
2. Limited number of hosts per segment
3. Chance of collision

B) Ring Topology:

- Multiple hosts are connected to circular ring
- Channel access mechanism over token ring
- Data is moving only in one direction



Advantages:

1. Gives better performance over bus topology
2. No chance of collision

Disadvantages:

1. If ring fail then topology will not work
2. Need network monitor for network maintenance

04. (b)

Sol:

(i) From the fig. we have,

$p(m_1) = 1 – p(m_0) = 1 – 0.5 = 0.5$

$p(r_0/m_0) = 1 – p(r_1/m_0) = 1 – p = 1 – 0.1 = 0.9$

$p(r_1/m_1) = 1 – p(r_0/m_1) = 1 – q = 1 – 0.2 = 0.8$

$\therefore p(r_0) = p(r_0/m_0)p(m_0) + p(r_0/m_1)p(m_1)$

$= 0.9 (0.5) + 0.2(0.5)$

$p(r_0) = 0.55$

$p(r_1) = p(r_1/m_0)p(m_0) + p(r_1/m_1)p(m_1)$

$= 0.1(0.5) + 0.8(0.5)$

$\therefore p(r_1) = 0.45$

(ii) Using baye's rule, we have,

$$p(m_0/r_0) = \frac{p(m_0)p(r_0/m_0)}{p(r_0)} = \frac{(0.5)(0.9)}{0.55} = 0.818$$

(iii) Similarly,

$$p(m_1/r_1) = \frac{p(m_1)p(r_1/m_1)}{p(r_1)} = \frac{(0.5)(0.8)}{0.45} = 0.889$$

(iv) $p_e = p(r_1/m_0)p(m_0) + p(r_0/m_1)p(m_1)$

$= 0.1(0.5) + 0.2(0.5)$

$\therefore\ p_e = 0.15$

(v) The probability that the transmitted signal is correctly read at receiver is

$p_e = p(r_0/m_0)\ p(m_0) + p(r_1/m_1)\ p(m_1)$

$= 0.9(0.5) + 0.8(0.5)$

$p_e = 0.85$

(or)

$p_e = 1 – p_e = 1 – 0.15$

$= 0.85$

04. (c)
Sol:

(i) Control Unit is the part of the computer's central processing unit (CPU), which directs the operation of the processor.
It is the responsibility of the Control Unit to tell the computer's memory, arithmetic/logic unit and input and output devices how to respond to the instructions that have been sent to the processor.
It fetches internal instructions of the programs from the main memory to the processor instruction register, and based on this register contents, the control unit generates a control signal that supervises the execution of these instructions.
A control unit works by receiving input information to which it converts into control signals, which are then sent to the central processor. The computer's processor then tells the attached hardware what operations to perform. The functions that a control unit performs are dependent on the type of CPU because the architecture of CPU varies from manufacturer to manufacturer.

Functions of the Control Unit:

- It coordinates the sequence of data movements into, out of, and between a processor's many sub-units.
- It interprets instructions.
- It controls data flow inside the processor.
- It receives external instructions or commands to which it converts to sequence of control signals.
- It controls many execution units(i.e. ALU, data buffers and registers) contained within a CPU.
- It also handles multiple tasks, such as fetching, decoding, execution handling and storing results.

(ii) **(A) File Structure:**

- A File Structure should be according to a required format that the operating system can understand.
- A file has a certain defined structure according to its type.
- A text file is a sequence of characters organized into lines.
- A source file is a sequence of procedures and functions.
- An object file is a sequence of bytes organized into blocks that are understandable by the machine.
- When operating system defines different file structures, it also contains the code to support these file structure. Unix, MS-DOS support minimum number of file structure.

(B) File Type:

File type refers to the ability of the operating system to distinguish different types of file such as text files source files and binary files etc. Many operating systems support many types of files. Operating system like MS-DOS and UNIX have the following types of files −

1. Ordinary files:

These are the files that contain user information.
These may have text, databases or executable program.
The user can apply various operations on such files like add, modify, delete or even remove the entire file.

2. Directory files:

These files contain list of file names and other information related to these files.

3. Special files:

These files are also known as device files.

These files represent physical device like disks, terminals, printers, networks, tape drive etc.
These files are of two types:

I. Character special files: Data is handled character by character as in case of terminals or printers.

II. Block special files: data is handled in blocks as in the case of disks and tapes.

05. (a)

Sol: $P_1 = 60\mu w$

$P_2 = 0.004\mu w$

P_3 - $26\mu w$

$P_4 = 27{,}5\mu w$

Excess loss $= 10\log_{10}\left(\dfrac{P_1}{P_3+P_4}\right)$

$= 10\log_{10}\dfrac{60}{53.5} = 0.5\text{dB.}$

Insertion loss (ports 1 to 3) = $10\log\left(\dfrac{P_1}{P_3}\right)$

$= 10\log\left(\dfrac{60}{26}\right)$

= 3.63 dB

Insertion loss (port 1 to 4) $= 10\log\left(\dfrac{60}{27.5}\right)$

= 3.39 dB

Cross talk $= 10\log\dfrac{P_2}{P_1}$

$= 10\log\dfrac{0.004}{60}$

$= -41.8\text{dB.}$

Split ratio $= \left(\dfrac{P_3}{P_3+P_4}\right)\times 100$

$= \dfrac{26}{53.5}\times 100$

= 48.6%

05. (b)

Sol: The intrinsic velocity of a wave in the material filling the wave guide is

$$\nu_1 = \frac{c}{\sqrt{\varepsilon_r}} = \frac{3\times 10^8}{\sqrt{9}} = 10^8\,\text{m/sec}$$

$$= \frac{c}{3}\,\text{m/sec}$$

$$\nu_{p_{TE}} = \frac{\nu_1}{\sqrt{1-\left(\dfrac{f_c}{f}\right)^2}} \;\ldots.(1)$$

Where $f_c = \dfrac{m\nu_1}{2a} = \dfrac{m\lambda_1 f}{2a}$

$\therefore \dfrac{f_c}{f} = \dfrac{m\lambda_1}{2a}$

For TE_3 mode m = 3

Substitute the above condition in equation (1)

$$\therefore \nu_{p_{TE_3}} = 1.4c = \frac{\nu_1}{\sqrt{1-\left(\frac{3\lambda_1}{2a}\right)^2}} = \frac{c}{3\sqrt{1-\left(\frac{3\lambda_1}{2a}\right)^2}}$$

$$\frac{\lambda_1}{a} = 0.647$$

The phase velocity for TM_2 mode is $V_{p_{TM2}} = \dfrac{\nu_1}{\sqrt{1-\left(\frac{2\lambda_1}{2a}\right)^2}}$

$$V_{p_{TM2}} = \frac{10^8}{\sqrt{1-(0.647)^2}} = 1.31\times10^8 \text{ m/sec}$$

The guided wavelength for

$$TM_2 = \frac{\nu_{p_{TM_2}}}{f} = \frac{1.31\times10^8}{1\times10^9} = 0.131 \text{ m}$$

05. (c)

Sol: Virtual Memory:

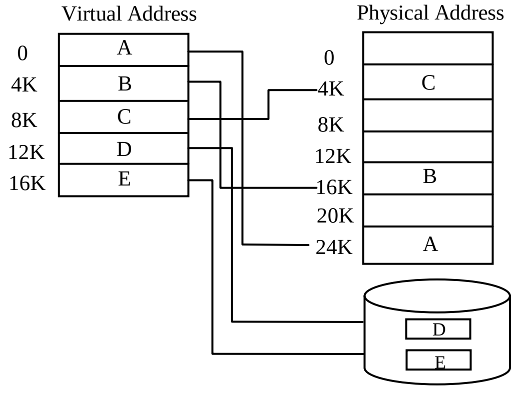
A computer can address more memory than the amount physically installed on the system. This extra memory is actually called virtual memory and it is a section of a hard disk that's set up to emulate the computer's RAM.

The main visible advantage of this scheme is that programs can be larger than physical memory. Virtual memory serves two purposes. First, it allows us to extend the use of physical memory by using disk. Second, it allows us to have memory protection, because each virtual address is translated to a physical address.

Following are the situations, when entire program is not required to be loaded fully in main memory.

- User written error handling routines are used only when an error occurred in the data or computation.
- Certain options and features of a program may be used rarely.
- Many tables are assigned a fixed amount of address space even though only a small amount of the table is actually used.
- The ability to execute a program that is only partially in memory would counter many benefits.
- Less number of I/O would be needed to load or swap each user program into memory.
- A program would no longer be constrained by the amount of physical memory that is available.
- Each user program could take less physical memory, more programs could be run the same time, with a corresponding increase in CPU utilization and throughput.

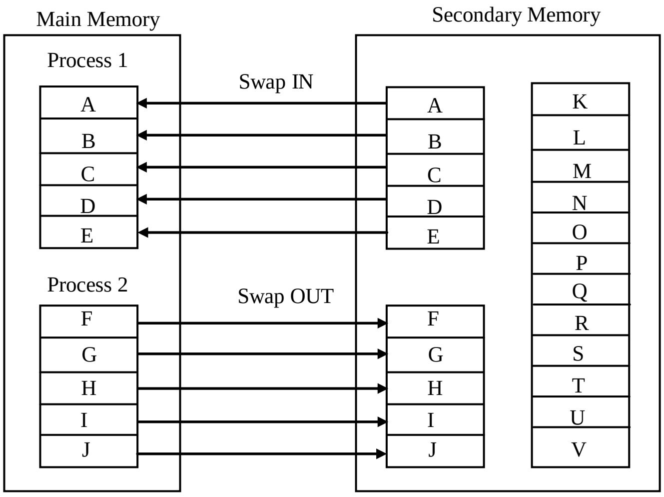
Modern microprocessors intended for general-purpose use, a memory management unit, or MMU, is built into the hardware. The MMU's job is to translate virtual addresses into physical addresses. A basic example is given below:



Virtual memory is commonly implemented by demand paging. It can also be implemented in a segmentation system. Demand segmentation can also be used to provide virtual memory.

Demand Paging

A demand paging system is quite similar to a paging system with swapping where processes reside in secondary memory and pages are loaded only on demand, not in advance. When a context switch occurs, the operating system does not copy any of the old program's pages out to the disk or any of the new program's pages into the main memory Instead, it just begins executing the new program after loading the first page and fetches that program's pages as they are referenced.



While executing a program, if the program references a page which is not available in the main memory because it was swapped out a little ago, the processor treats this invalid memory reference as a page fault and transfers control from the program to the operating system to demand the page back into the memory.

Advantages

- Large virtual memory.
- More efficient use of memory.
- There is no limit on degree of multiprogramming.

Disadvantages

Number of tables and the amount of processor overhead for handling page interrupts are greater than in the case of the simple paged management techniques.

05. (d)

Sol: $G(s)H(s) = \dfrac{K}{\left(1+\frac{1}{b}s\right)} \Rightarrow |G(j\omega)H(j\omega)| = \dfrac{K}{\sqrt{1+\left(\frac{1}{b}\omega\right)^2}}$

at $\omega = 5b \Rightarrow M = \dfrac{K}{\sqrt{1+\left[\frac{1}{b}(5b)\right]^2}} = \dfrac{K}{\sqrt{26}}$

$$M_{dB} = 20\log\left(\frac{K}{\sqrt{26}}\right) = 20\log K - 20\log\sqrt{26}$$

$M_{dB} = 20\log K - 14.14\text{dB}$. ------------- (1)

From the Bode plot given at

$\omega = 5b \Rightarrow$ slope = –20dB/dec.

at $\omega_1 = b \Rightarrow M_1 = 20\log K$

$\omega_2 = 5b \Rightarrow M_2 = ?$

$$\text{slope} = \frac{M_2 - M_1}{\log\omega_2 - \log\omega_1}$$

$$-20 = \frac{M_2 - 20\log K}{\log(5b) - \log(b)} = \frac{M_2 - 20\log K}{\log\left(\frac{5b}{b}\right)}$$

$$M_2 - 20\log K = -20(\log 5) = -13.979$$

$M_2 = 20\log K - 13.979$ --------------------- (2)

Equation (1) is exact analysis, equation (2) is approximate analysis.

Error = exact – approximate.

= (20logK – 14.14) – (20logK – 13.97)

= – 0.161 dB

Magnitude = 0.16 dB

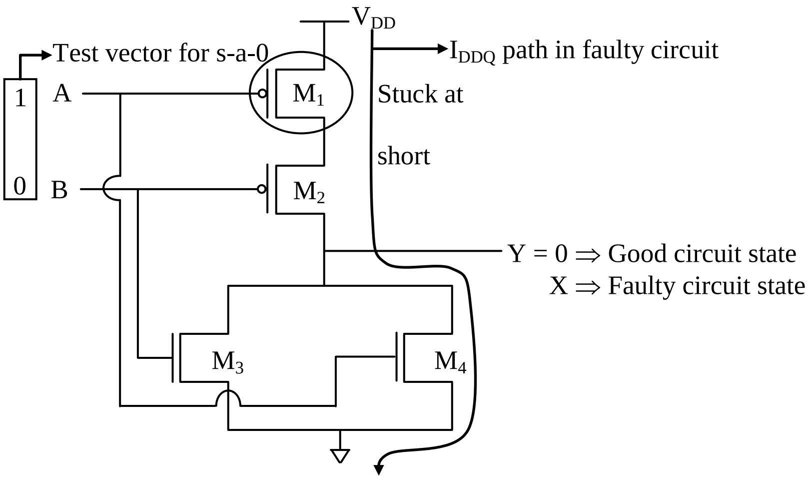
05. (e)

Sol: Stuck - short fault:

When a transistor is permanently shorted irrespective of its gate voltage then the transistor is in a state of stuck - short fault.

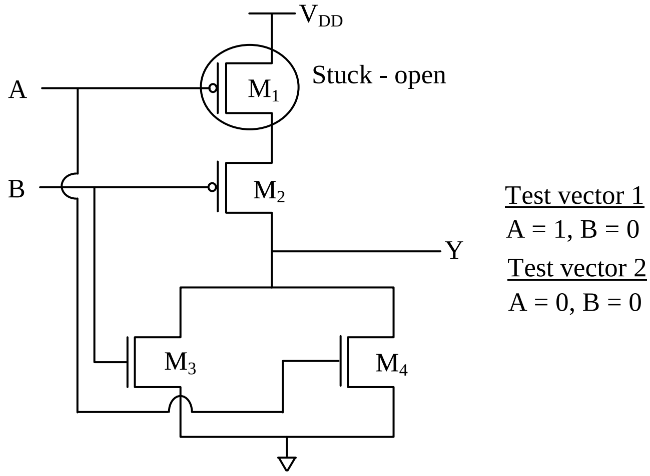
Detection of a stuck-short fault requires the measurement of quiescent current (I_{DDQ}).

Example:



The above circuit shows an OR gate in which M_1 is at stuck at short. To detect stuck short, a test vector of A = 1 and B = 0 is applied. If the output is logic 0 for this test vector then we can conclude that the gate is working properly otherwise we can say that M_1 is stuck at short.

Stuck - open fault:



When a single transistor is permanently irrespective of its gate voltage then the transistor is in a state of stuck - open fault. Detection of stuck - open fault requires two test vectors. When test vector 1 and 2 are applied simultaneously, if output y changes from 0 to 1 then no fault is present, if output y changes from 0 to high impedance (Z) then stuck - open fault had occurred to M_1.

06. (a)

Sol:

(i) $|\overline{E}| = \dfrac{k}{\rho}$

$$W_E = \frac{\varepsilon_0}{2}\int |\overline{E}|^2 \, dv$$

$$= \frac{\varepsilon_0}{2}\int_2^3\int_0^{\pi/2}\int_5^7 \frac{k^2}{\rho^2}\times\rho \, d\rho \, d\phi \, dz$$

$$= \frac{\varepsilon_0}{2}\times k^2 \times [\ln\rho]_2^3[\phi]_0^{\pi/2}[z]_5^7$$

$$= k^2 \times \frac{10^{-9}}{36\pi\times 2}\times \ln\left(\frac{3}{2}\right)\times\frac{\pi}{2}\times 2$$

$$= k^2 \times \frac{10^{-9}}{72}\times \ln\left(\frac{3}{2}\right)$$

$W_E = 1\mu J = 10^{-6}$

$$\Rightarrow k^2 \times \frac{10^{-9}}{72}\times \ln\left(\frac{3}{2}\right) = 10^{-6}$$

$$\Rightarrow k^2 = \frac{72}{10^{-3}\times \ln\left(\frac{3}{2}\right)} = 177573.84$$

$\Rightarrow k = 421.39$

(ii) Point P is above conducting plane z = 2 . If we drop a perpendicular from point P on the plane z = 2, the coordinate of the foot of the perpendicular will be (2,–3,2). Hence the distance of point P from the z = 2 plane is

$$\sqrt{(2-2)^2+(-3+3)^2+(5-2)^2}=3.$$

Consider a point P′ which is mirror image of point P. The distance of point P′ from the plane z = 2 will be 3. Hence the co ordinate of point p′ be (2, –3, –1). If a perpendicular is dropped from P′ on plane z = 2, the co ordinates of foot of perpendicular will be (2, –3, 2). At this point P′, the charge of –25nC(which is image of 25nC) is located.

since no point is mentioned we calculate potential at origin.

V at (0, 0, 0) is – V due to 25nC + V due to –25nC

$$=\frac{25\times10^{-9}}{4\pi\varepsilon_0\sqrt{(2)^2+(3)^2+(5)^2}}+\frac{-25\times10^{-9}}{4\pi\varepsilon_0\sqrt{(2)^2+(3)^2+(1)^2}}$$

= –23.632V

06. (b)

Sol: We have

$\Delta f = (\Delta f_1)(n_1)(n_2) = (25)(64)(48)$

$\Delta f = 76.8$kHz

$f_2 = nf_1 = (64)(200)(10^3) = 12.8(10^6)$Hz = 12.8 MHz

let $f_3 = f_2 \pm f_{LO} = (12.8 \pm 10.8)(10^6)$ Hz

$$=\begin{cases}23.6\text{MHz}\\2.0\text{MHz}\end{cases}$$

Thus when f_3 = 23.6 MHz, then we have

$f_c = n_2f_3 = (48)(23.6) = 1132.8$ MHz

when f_3 = 2MHz, then

$f_c = n_2f_3 = (48)(2)$

= 96MHz

06. (c)

Sol: Given f_s = 32,000 samples/sec

Peak value of signal A = 2V

BW = 4kHz

(1) Step size 'Δ' to avoid slope overload

$$A\le\frac{\Delta f_s}{2\pi f_m}$$

$$2\le\frac{\Delta\times32{,}000}{2\pi\times4\times10^3}$$

$\Delta \ge 1.57$ volt

∴ step size ≥ 1.57 volts

(2) Quantization Noise power (Nq)

$$Nq=\frac{\Delta^2}{3}=\frac{(1.57)^2}{3}=0.822\,W$$

(3) $$\text{SNR}=\frac{3f_s^3}{8\pi^2f_m^2(Bw)}=\frac{3\times(32\times10^3)^3}{8\pi^2(4\times10^3)^2(4\times10^3)}$$

SNR = 19.45

06. (d)

Sol: Time Scaling Property

The time scaling property states that, if

$$x(t) \xleftrightarrow{FS} C_n$$

$$\text{then} \quad x(\alpha t) \xleftrightarrow{FS} C_n \text{ with } \omega_0 \rightarrow \alpha\omega_0$$

Proof: From the definition of Fourier series, we have

$$x(t) = \sum_{n=-\infty}^{\infty} C_n e^{jn\omega_0 t}$$

$$\therefore x(\alpha t) = \sum_{n=-\infty}^{\infty} C_n e^{jn\omega_0 \alpha t} = \sum_{n=-\infty}^{\infty} C_n e^{jn(\alpha\omega_0)t} = FS^{-1}[C_n]$$

where $\omega_0 \rightarrow \alpha\omega_0$

$\therefore x(\alpha t) \xleftrightarrow{FS} C_n$ with fundamental frequency of $\alpha\omega_0$ proved.

Time Differentiation Property

The time differentiation property states that, if

$$x(t) \xleftrightarrow{FS} C_n$$

$$\text{then} \quad \frac{dx(t)}{dt} \xleftrightarrow{FS} jn\omega_0 C_n$$

Proof: From the definition of Fourier series, we have

$$x(t) = \sum_{n=-\infty}^{\infty} C_n e^{jn\omega_0 t}$$

Differentiating both sides with respect to t, we get

$$\frac{dx(t)}{dt} = \sum_{n=-\infty}^{\infty} C_n \frac{d\left(e^{jn\omega_0 t}\right)}{dt} = \sum_{n=-\infty}^{\infty} C_n (jn\omega_0) e^{jn\omega_0 t}$$

$$= \sum_{n=-\infty}^{\infty} (jn\omega_0 C_n) e^{jn\omega_0 t} = FS^{-1}[jn\omega_0 C_n]$$

$$\frac{dx(t)}{dt} \xleftrightarrow{FS} jn\omega_0 C_n \text{ Proved.}$$

07. (a)

Sol: The characteristic equation is $s^2 + 1.6s + 16 = 0$. Comparing with the second order characteristic equation i.e.

$$s^2 + 2\zeta\omega_n s + \omega_n^2 = 0$$

$$2\zeta\omega_n = 1.6$$

and $\omega_n = \sqrt{16} = 4$ rad/sec

therefore, the damping ratio for the system without derivative feedback control is

$$\zeta = \frac{1.6}{2\omega_n} = \frac{1.6}{2\times 4} = 0.2$$

The damping ratio with derivative feedback control is given by

$$\zeta' = \zeta + \frac{\omega_n K_t}{2}$$

As the damping ratio is to be made 0.8 and $\omega_n = 4$ rad/sec

$$0.8 = 0.2 + \frac{4K_t}{2}$$

$$K_t = 0.3$$

(i) Without derivative feedback control:

$$\text{Rise time } t_r = \frac{\pi - \tan^{-1}\left(\frac{\sqrt{1-\zeta^2}}{\zeta}\right)}{\omega_n\sqrt{1-\zeta^2}}$$

$$= \frac{\pi - \tan^{-1}\left(\frac{\sqrt{1-0.2^2}}{0.2}\right)}{4\sqrt{1-0.2^2}}$$

$$= \frac{\pi - \tan^{-1} 4.89}{4\times 0.98} = 0.45 \text{ sec}$$

$$\text{Peak time } t_p = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}} = \frac{\pi}{4\sqrt{1-0.2^2}} = \frac{\pi}{4\times 0.98} = 0.8 \text{ sec}$$

% maximum overshoot

$$M_p = e^{-\frac{\zeta\pi}{\sqrt{1-\zeta^2}}\times 100} = e^{-\frac{0.2\pi}{\sqrt{1-0.2^2}}}\times 100$$

$$= e^{-0.64}\times 100 = 52.6\%$$

Steady state error

$$e_{ss} = \frac{2\zeta}{\omega_n} = \frac{2\times 0.2}{4} = 0.1$$

(ii) With derivative feedback control

The overall transfer function of the system using derivative feedback control is given by

$$\frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2 + (2\zeta\omega_n + \omega_n^2 K_t)s + \omega_n^2}$$

Given that $\zeta = 0.2$, $\omega_n = 4$ and $K_t = 0.3$

$$\therefore \frac{C(s)}{R(s)} = \frac{4^2}{s^2 + (2\times 0.2\times 4\times + 4^2\times 0.3)s + 4^2}$$

Or $\frac{C(s)}{R(s)} = \frac{16}{s^2 + 6.4s + 16}$

$2\zeta'\omega_n = 6.4$ and $\omega_n = 4$

$\zeta' = \frac{6.4}{2\omega_n} = \frac{6.4}{24} = 0.8$

Rise time $t_r = \frac{\pi - \tan^{-1}\left(\frac{\sqrt{-\zeta^2}}{\zeta'}\right)}{\omega_n\sqrt{1-\zeta^2}} = \frac{\pi - \tan^{-1}\left(\frac{\sqrt{1-0.8^2}}{0.8}\right)}{4\sqrt{1-0.8^2}}$

$= \frac{\pi - \tan^{-1} 0.75}{2.4} = \frac{\pi - 0.64}{2.4} = 1.04$ sec

Peak time $t_p = \frac{\pi}{\omega_n\sqrt{1-\zeta'^2}} = \frac{\pi}{4\sqrt{1-0.8^2}} = 1.3$ sec

% Maximum overshoot

$M_p = e^{-\frac{\zeta'\pi}{\sqrt{1-\zeta'^2}}\times 100} = e^{-\frac{0.8\pi}{\sqrt{1-0.8^2}}\times 100} = e^{-4\pi/3} \times 100 = 1.52\%$

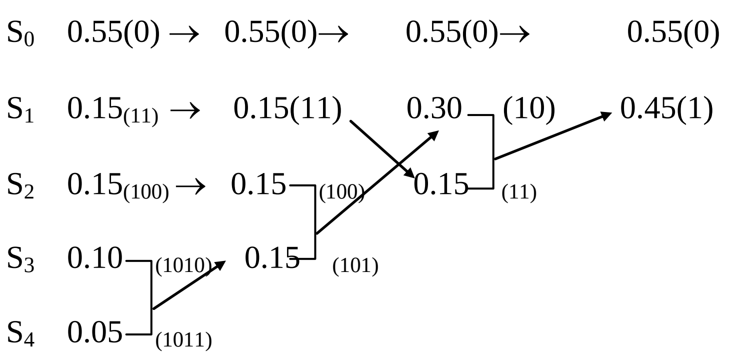
Steady state error $e_{ss} = \frac{2\zeta}{\omega_n} + K_t = \frac{2\times 0.2}{4} + 0.3 = 0.4$

	Without derivative feedback control	With derivative feedback control
Damping ratio ζ	0.2	0.8
Rise time t_r	0.45 sec	1.04 sec
Peak time t_p	0.8 sec	1.3 sec
% maximum overshoot M_p	52.6%	1.52%
Steady state error e_{ss}	0.1	0.4

07. (b)

Sol:

(i) Huffman code generated by placing a combined symbol as low as possible:



The source code is therefore

S_0 0

S_1 11

S_2 100
S_3 1010
S_4 1011

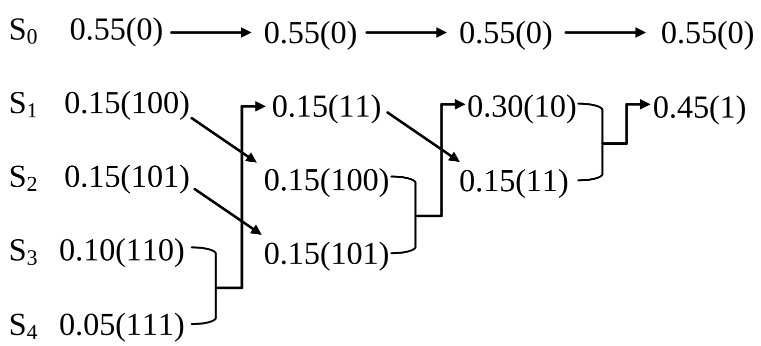
The average code word length is

$$L = \sum_{K=0}^{4} P_K \ell_K$$
$$= (0.55 \times 1) + (0.15 \times 2) + (0.15 \times 3) + (0.10 \times 4) + (0.05 \times 4)$$
$$= 1.9$$

The Variance of average code word length is

$$\sigma^2 = \sum_{K=0}^{4} P_K (\ell_K - L)^2$$
$$= [0.55 \times (1 - 1.9)^2] + [0.15 \times (2 - 1.9)^2] + [0.15 \times (3 - 1.9)^2] + [0.1 \times (4 - 1.9)^2] + [0.05 \times (4 - 1.9)^2]$$
$$= 0.4455 + 0.0015 + 0.1815 + 0.441 + 0.2205$$
$$= 1.29$$

(ii) Next placing a combined symbol as high as possible, we obtain the 2nd Huffman code:



The average code-word length is

$$L = (0.55 \times 1) + (0.15 + 0.15 + 0.10 + 0.05) \times 3$$
$$= 1.9$$

The variance of L is =

$$\sigma^2 = [0.55 \times (1 - 1.9)^2] + [0.15 \times (3 - 1.9)^2] + [0.15 \times (3 - 1.9)^2] + [0.10 \times (3 - 1.9)^2] + [0.05 \times (3 - 1.9)^2]$$
$$= 0.4455 + 0.1815 + 0.1815 + 0.121 + 0.0605$$
$$= 0.99$$

The two Huffman codes described herein have the same average code-word length but different variances.

07. (c)

Sol: The signal shown in Figure can be expressed as:

$$x(t) = \begin{cases} A\sin\omega_0 t & ; 0 < t < T/2 \\ 0 & ; \text{ elsewhere} \end{cases}$$

$$\therefore \quad X(\omega) = F[x(t)] = \int_{-\infty}^{\infty} x(t) e^{-j\omega t} dt$$

$$= \int_0^{T/2} A\sin(\omega_0 t)e^{-j\omega t}dt = A\int_0^{T/2}\left(\frac{e^{j\omega_0 t}-e^{-j\omega_0 t}}{2j}\right)e^{-j\omega t}dt$$

$$= \frac{A}{2j}\left[\int_0^{T/2} e^{-j(\omega-\omega_0)t}dt - \int_0^{T/2} e^{-j(\omega+\omega_0)t}dt\right] = \frac{A}{2j}\left[\frac{e^{-j(\omega-\omega_0)t}}{-j(\omega-\omega_0)} - \frac{e^{-j(\omega+\omega_0)t}}{-j(\omega+\omega_0)}\right]_0^{T/2}$$

$$= \frac{A}{2j}\left[\frac{e^{-j(\omega-\omega_0)T/2}-1}{-j(\omega-\omega_0)} - \frac{e^{-j(\omega+\omega_0)T/2}-1}{-j(\omega+\omega_0)}\right]$$

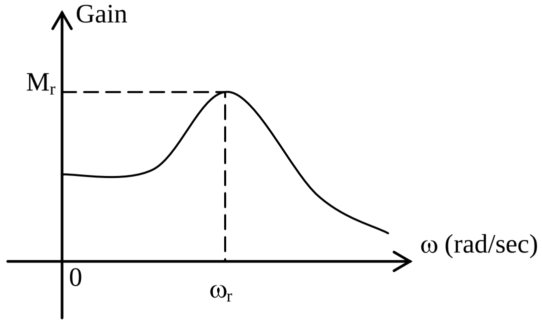
$$= \frac{A}{2}\left[\frac{1}{\omega+\omega_0} - \frac{1}{\omega-\omega_0} + \frac{e^{-j\omega(T/2)}e^{j\omega_0(T/2)}}{\omega-\omega_0} - \frac{e^{-j\omega(T/2)}e^{-j\omega_0(T/2)}}{\omega+\omega_0}\right]$$

$$= \frac{A}{2}\left[\frac{-2\omega_0}{\omega^2-\omega_0^2} - \frac{e^{-j\omega(T/2)}}{\omega-\omega_0} + \frac{e^{-j\omega(T/2)}}{\omega+\omega_0}\right] \qquad \left(e^{j\omega_0(T/2)} = e^{j\pi} = -1\right)$$

$$= \frac{A}{2}\left\{\frac{-2\omega_0}{\omega^2-\omega_0^2} + \left[\frac{(\omega-\omega_0)-(\omega+\omega_0)}{\omega^2-\omega_0^2}\right]e^{-j\omega(T/2)}\right\} = \frac{A}{2}\left[\frac{2\omega_0}{\omega_0^2-\omega^2}\left(1+e^{-j\omega(T/2)}\right)\right]$$

$$= \frac{A\omega_0}{\omega_0^2-\omega^2}e^{-j\omega T/4}\left(e^{j\omega T/4}+e^{-j\omega T/4}\right) = \frac{2A\omega_0}{\omega_0^2-\omega^2}e^{-j\omega T/4}\cos\omega\frac{T}{4}$$

08. (a)
Sol:



Characteristics of gain Vs frequency

Resonant frequency (ω_r): The frequency at which maximum magnitude occurs.

Transfer function of a second order proto type system is, $\frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2}$

Sinusoidal transfer function is,

$$\frac{C(j\omega)}{R(j\omega)} = \frac{\omega_n^2}{(j\omega)^2+2\xi\omega_n(j\omega)+\omega_n^2}$$

$$= \frac{1}{1-\left(\frac{\omega}{\omega_n}\right)^2 + j2\xi\left(\frac{\omega}{\omega_n}\right)}$$

Let $\frac{\omega}{\omega_n} = \mu$

$$= \frac{1}{(1-\mu^2) + j2\xi\mu}$$

Magnitude,

$$M = \left|\frac{C(j\omega)}{R(j\omega)}\right| = \frac{1}{\sqrt{(1-\mu^2)^2 + (2\xi\mu)^2}}$$

To get maximum value of magnitude (M),

$$\frac{dM}{d\mu} = 0$$

$$\frac{-2((1-\mu^2)(-2\mu)) + (8\xi^2)\mu}{2\sqrt{(1-\xi^2)^2 + (2\xi\mu)^2}} = 0$$

$$[2(1-\mu^2)(-2\mu)] = -8\xi^2\mu$$

$$-4\mu(1-\mu^2) + 8\mu\xi^2 = 0$$

$$-4\mu + 4\mu^3 + 8\mu\xi^2 = 0$$

$$8\xi^2 + 4\mu^2 - 4 = 0$$

$$2\xi^2 + \mu^2 - 1 = 0$$

$$\mu = \sqrt{1-2\xi^2}$$

$$\frac{\omega}{\omega_n} = \sqrt{1-2\xi^2}, \quad \omega_r = \omega_n\sqrt{1-2\xi^2}$$

The resonant peak obtained by substituting ω_r in magnitude

$$\left|\frac{C(j\omega)}{R(j\omega)}\right| = \frac{1}{\sqrt{(1-\mu^2)^2 + 4\xi^2\mu^2}} = \frac{1}{\sqrt{(1-1+2\xi^2)^2 + 4\xi^2(1-2\xi^2)}}$$

$$= \frac{1}{\sqrt{4\xi^4 + 4\xi^2 - 8\xi^4}}$$

$$\therefore \ M_r = \frac{1}{2\xi\sqrt{1-\xi^2}}$$

- Given that $G(s) = \frac{25}{s(s+6)}$

  Characteristic equation is 1 + G(s) = 0

$$1 + \frac{25}{s(s+6)} = 0$$

$$s(s+6) + 25 = 0$$

$$s^2 + 6s + 25 = 0 \rightarrow (1)$$

Characteristic equation of prototype second order system is

$$s^2 + 2\xi\omega_n s + \omega_n^2 = 0 \rightarrow (2)$$

Compare eq (1) and (2) then we get

$\omega_n = 5$ $\quad$ $\xi = 0.6$

Resonant frequency $\omega_r = \omega_n \sqrt{1-2\xi^2}$

$$= 5\sqrt{1-0.72} = 5\sqrt{0.28} = 2.6$$

$\therefore \omega_r = 2.6$ rad/sec

$$M_r = \frac{1}{2\xi\sqrt{1-\xi^2}}$$

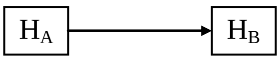
$$M_r = \frac{1}{2\times 0.6\sqrt{1-(0.6)^2}} = \frac{1}{1.2\sqrt{0.64}} = \frac{1}{0.96}$$

$M_r = 1.04$

08. (b)

Sol: Simplex:

- Communication channel only send information in one direction
- One way communication
- Radio station is simplex channel



Duplex:

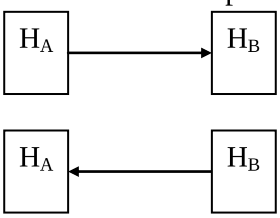
Duplex communications are of two types:

i) Half Duplex

ii) Full Duplex

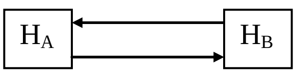
i) Half Duplex:

- Either side communication at one time
- Information can be send in any direction, but at one time only in one direction
- Walkie-talkie is half duplex channel



ii) Full duplex:

- Data can be transmitted in both directions simultaneously
- Telephone is full duplex channel



08. (c)

Sol:

(i) Given E_{yo} = 300 V/m, f = 7 GHz

a = 9 cm & b = 6 cm.

In TE_{mn} mode (for both m & n $\neq$ 0):-

$$\frac{E_{yo}}{E_{xo}} = \frac{mb}{na} \Rightarrow E_{xo} = \frac{na}{mb} E_{yo}$$

$\therefore$ for TE_{21} mode

$$\therefore E_{xo} = \frac{a}{2b} E_{yo} = \frac{9}{2\times 6} \times 300 = 225 V/m$$

$$\frac{E_{yo}}{H_{xo}} = \eta_{TE_{21}}, \quad \& \quad \frac{E_{xo}}{H_{yo}} = \eta_{TE_{21}}$$

$$\therefore H_{xo} = \frac{E_{yo}}{\eta_{TE_{21}}} \qquad H_{yo} = \frac{E_{xo}}{\eta_{TE_{21}}}$$

$$\eta_{TE_{21}} = \frac{\eta_o}{\sqrt{1-\left(\frac{f_{c_{21}}}{f}\right)^2}}$$

Where $f_{c_{21}} = \frac{C}{2}\sqrt{\left(\frac{2}{a}\right)^2 + \left(\frac{1}{b}\right)^2} = \frac{3\times 10^{10}}{2}\sqrt{\left(\frac{2}{9}\right)^2 + \left(\frac{1}{6}\right)^2}$

$= 4.16$ GHz.

$$\therefore \eta_{TE_{21}} = \frac{120\pi}{\sqrt{1-\left(\frac{4.16\times 10^9}{7\times 10^9}\right)^2}} = 468.74\Omega$$

$$\therefore H_{xo} = \frac{E_{yo}}{\eta_{TE_{21}}} = \frac{300}{468.74} = 0.64 A/m$$

$$\therefore H_{yo} = \frac{E_{xo}}{\eta_{TE_{21}}} = \frac{225}{465.74} = 0.48 A/m.$$

(ii) $v_{g_{10}} = 2\times 10^8$ m/sce $\qquad$ [$\because$ dominant mode $\Rightarrow TE_{10}$]

$$v_{g_{10}} = \frac{c}{\sqrt{\varepsilon_r}}\sqrt{1-\left(\frac{f_{c_{10}}}{f}\right)^2}$$

$$\left[\frac{v_{g_{10}}\sqrt{\varepsilon_r}}{c}\right]^2 = 1-\left(\frac{f_{c_{10}}}{f}\right)^2$$

$$f_{c_{10}} = f\left[1-\frac{v_g^2 \varepsilon_r}{c^2}\right]^{1/2}$$

$$\therefore f_{c_{10}} = 3\times 10^9 \sqrt{\left[1-\frac{4\times 10^{16}\times 2}{9\times 10^{16}}\right]}$$

$$\therefore f_{c_{10}} = 1\, GHz$$

$$f_{c_{10}} = \frac{c}{2a\sqrt{\varepsilon_r}}$$

$$a = \frac{c}{2 f_{c_{10}}\sqrt{\epsilon_r}} = \frac{3\times 10^{10}}{2\times 1\times 10^9\sqrt{2}}$$

a = 10.606 cm.(or) 0.106 m.

$\therefore$ Size of the cross section of sq.w/g is 10.606 cm × 10.606 cm